Level of agreement between midwives and obstetricians performing ultrasound examination during labor

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KEYWORDS: Ultrasound; labor; childbirth; midwives; cervical dilatation; cervical examination.

SYNOPSIS:

- Ultrasound assessment of fetal head position and progress of labor can effectively be performed by attending midwives without prior experience on ultrasound.

NUMBER OF WORDS: 2476 2544

Clinical article

ABSTRACT

OBJECTIVE: Our objective was to evaluate the level of agreement between the ultrasound measurements to evaluate fetal head position and progress of labor by attending midwives and obstetricians after appropriate training.

METHODS: In this prospective study, women at first stage of labor giving birth a single baby in cephalic presentation at our Obstetric Unit between March 2018-December 2019 were invited to participate; 109 women agreed. Transperineal and transabdominal ultrasound was independently performed by a trained midwife and an obstetrician. Two paired measurements were available for comparisons in 107 cases for the angle of progression (AoP), 106 cases for the head-to-perineum distance (HPD), 97 cases for the cervical dilatation (CD), and 79 cases for the fetal head position.

RESULTS: We found a good correlation between the AoP measured by obstetricians and midwives (ICC=0.85; 95%CI: 0.80-0.89). There was a moderate correlation between the HPD (ICC=0.75; 95%CI: 0.68-0.82). There was a very good correlation between the CD measured (ICC=0.94; 95%CI: 0.91-0.96). There was a very good level of agreement in the classification of the fetal head position (Kw=0.89; 95%CI: 0.80-0.98).

CONCLUSIONS: Ultrasound assessment of fetal head position and progress of labor can effectively be performed by attending midwives without prior experience on ultrasound.

INTRODUCTION

Serial vaginal examinations constitute the routine intervention to assess the progress of labor. Together with the partogram, it provides a graphical view of the process and allows identify early signs of labor dystocia[1]. Despite being considered the gold standard method, it lacks good evidence of effectiveness and is not exempt from potential risks[2]. Vaginal examination is a subjective approach; the reproducibility between operators is suboptimal and increases the risk of infection for both mother and baby[3]. Some women perceive vaginal examination as uncomfortable, painful or even abusive[3,4]. For all these reasons, ultrasound has emerged as a complementary and valuable non-invasive technique for assessing labor progress objectively, reproducibly, confidently, safely, and well tolerated[5,6,7]. In addition, ultrasound can objectively assess fetal presentation, placenta localization, and is also~~cervical dilatation. It can also be a~~ helpful tool for evaluating fetal heart rate, cervical dilatation (CD) or assisting the vaginal birth of the second twin[8,9].

Labor progress by ultrasound is assessed with parameters that correlate the anatomical landmarks of the pelvis with the fetal head[10]. Visualizing the fetal head and the pubis makes it possible to evaluate the fetal head station and flexion through the angle of progression(AoP), the head direction, and the progression distance[9,11,12]. AoP is the most widely used sonographic parameter; it is defined as the angle between the long axis of the pubic symphysis and a line from the inferior border of the symphysis tangential to the fetal skull. The AoP can be easily converted into head station, and different cut-offs have been established with significant prognostic value. For example, 120 degrees equals a head station of 0 and either an successful vacuum extraction or spontaneous vaginal delivery[5,9,11]. Another widely used sonographic parameter to observe the fetal head station is the head-perineum

distance(HPD), which does not depend on the visualization of the maternal pubis and may be a predictor. Different HPD values are important prognostic factors for vaginal delivery or the success of labor induction[13]. The position of the fetal head can be evaluated by transperineal and transabdominal ultrasound, observing cranial structures (orbits, interhemispheric midline, or cerebellum)[14]. Finally, cervical dilatation(CD) is evaluated by transperineal ultrasound by measuring the anteroposterior diameter of the cervical opening[8].

In many countries, the management of labor for low-risk women is midwifery-led. Midwives accompany the women throughout their pregnancy, during the birth and the postpartum period, unless there are complications. Therefore, if any new tool is meant to be introduced into the routine clinical management of labor and delivery, midwives must be involved. It has previously been demonstrated that trained midwives can effectively acquire ultrasound skills to visualize fetal heartbeat and movements and identify placental location following an appropriate training program[15]. However, only two studies evaluating the role of ultrasound in labor have included a small number of midwives to perform the assessments[13,16]. Only one small study (n=30) has compared results from ultrasound examinations carried out by midwives with those performed by obstetricians, and the authors have only found a moderate agreement between them[17].

The main objective of our study was to evaluate the level of agreement between the ultrasound measurements taken for the evaluation of fetal head position and progress of labor betweeny attending midwives and obstetricians in a real labor/ward setting.

MATERIALS AND METHODS

This was a prospective comparative study carried out at two maternity units (Hospital Universitario de Torrejón and Hospital Universitario La Paz), in Madrid, Spain. Women

at first stage of labor giving birth a single term baby in cephalic presentation ~~at term at~~in our Obstetric Units between March 2018 and December 2019 were invited to participate in the study, regardless of their prior risk for delivery, parity, labor onset or the status of the amniotic membranes. The only exclusion criterion was planned cesarean sections. The study was approved by the local research ethics committee (Hospital Universitario de Getafe, reference A10/17) and written informed consent was obtained ~~from all the participants after information had been provided~~.

We recorded the following maternal and pregnancy characteristics: maternal age, pre-pregnancy weight, and pregnancy weight gain, method of conception (natural/assisted conception), cigarette smoking during pregnancy (yes/no), parity (parous or nulliparous if no previous pregnancy at ≥ 24 weeks' gestation), diabetes mellitus and chronic hypertension (yes/no) and gestational age at admission. All variables and results of the ultrasound investigations and pregnancy outcome were recorded in a secure computer database (~~with~~ ViewPoint software, ~~(~~GE Healthcare; Munich, Germany).

After obtaining informed consent, one obstetrician and one midwife, blinded to each other's ultrasound findings and the findings of the clinical examination, carried out the ultrasound scan in random order. ~~The ultrasound examination order by the midwife and the obstetrician was random.~~ Examinations performed more than one hour apart between the two operators were excluded from the analysis. During the ultrasound scan, the fetal head position and the AoP, HPD, and CD were assessed with a Voluson S8 (GE Healthcare; Zipf, Austria) ultrasound machine with convex transducers (RAB6-RS or 4C-RS) and SonoL&D software. Each woman was assessed only once by the obstetrician and midwife. The position of the fetal head was classified using the number of the quadrant in which the lambda fontanelle was located, following the scheme represented in Figure 2.

Before any *ultrasound assessment,* urinary bladder was emptied. The women were requested to lie in a semi-recumbent position with their legs flexed. First, the fetal head position was evaluated transabdominal, and then, the ultrasound transducer was placed on the vulva to measure the AoP, HPD, and CD as previously described[5,8]. Figure 1 provides a visual explanation of how to measure those.

Before starting the study, the most experienced obstetrician in labor ultrasound provided a short training course to a selected group of attending midwives with no experience in ultrasound and to obstetricians with extensive experience in ultrasound but who had never performed transperineal ultrasound during labor. Firstly, it consisted of a one-hour theoretical introduction on how to use the ultrasound machine, complete the assessment and take the relevant measurements. We used the International Society of Ultrasound in Obstetrics of Gynecology (ISUOG) guidelines to standardize the measurement of the AoP, HPD, and CD by transperineal ultrasound[10]. The second part of the course consisted of hands-on training on consenting pregnant women, supervised by an experienced fetal medicine specialist. To complete the training process, both midwives and obstetricians were requested to take at least five satisfactory ultrasound measurements[13].

For Statistical analysis, descriptive data were expressed as median and interquartile range (IQR) and in proportions (absolute and relative frequencies). The absolute paired differences were calculated.~~Comparisons between operator groups were performed by Wilcoxon Signed Rank test or two-tailed χ2 test as appropriate.~~

Intra-class correlation coefficients(ICC) were calculated to analyze the inter-observer variability of the numerical variables (AoP, HPD, and CD)[18]. The weighted Cohen's Kappa(K_w) was computed based on a two-way random-effects model to assess the level of agreement between the two operators classifying the fetal head position. To favor

correct identification of the fetal sagittal suture, disagreements in one position (adjacent quadrant) were penalized stronger than those in two positions (opposed quadrant) by assigning the former 0% of the total agreement weight and the latter 50% of the total agreement weight; in a more technical way, all diagonal cells had weight 1, all adjacent weight 0.5 and all the others weight 0. The values for both statistics, ICC and K_w, range from zero (the agreement is likely to have occurred by chance) to one (perfect arrangement). The level of agreement was considered very good when the K_w was >0.80, good between 0.60 and 0.80, moderate between 0.40 and 0.60, fair between 0.20 and 0.40, and poor if <0.20[19]. For the ICC assessment, >0.90 was considered very good; between 0.80 and 0.90, it was considered good, and between 0.60 and 0.80, moderate and poor if <0.60. 95% confidence intervals (CI) and ~~p values~~ were also obtained. Finally, we also used Bland and Altman figures to graphically assess the differences between the paired measurements (y-axis) and their mean (x-axis)[20]. When there is a good agreement, the values tend to group close to the horizontal line, representing complete agreement.~~-~~ Mean of differences, limits of agreement and 95% CI are reported~~To assess the magnitude of the difference, Wilcoxon signed-rank test for continuous variables was also calculated to obtain the median of the differences with 95% CI~~. Analyses were run on a complete case basis, and the number of pregnancies included in each analysis was reported wherever necessary.~~ Level of significance was set at 0.05.~~

The statistical software package R version 4.2.2~~3.9~~ and its packages "Psych"[21], "BlandAltmanLeh" [x] and "ggplot2" [x] were used for data analyses.

RESULTS

During the study period, 109 women accepted to participate in the study, and only four women declined. Maternal and pregnancy characteristics are reported in Table 1. 31

attending midwives and ten obstetricians were trained before the start of the study. We had paired measurements available for comparisons in 107 (98.17%) cases for the AoP, 106 (97.25%) cases for the HPD, 97 (88.99%) cases for the CD; and 79 (72.45%) cases of the fetal head position. Results from ultrasound examinations are summarized in Table 2.

We found a good correlation between the AoP measured by midwives and obstetricians (ICC=0.85; 95% CI: 0.80 to 0.89, Figure 3) ~~with a difference of the medians of 2.5 degrees (95% CI: 0.0 to 5.0, Figure 3)~~. There was a moderate correlation between the HPD measured by midwives and obstetricians (ICC=0.75; 95% CI: 0.68 to 0.82~~) with a difference of the medians of 0.04 cm (95% CI: -0.15 to 0.21~~, Figure 4). There was a very good correlation between the CD measured by midwives and obstetricians (ICC=0.94; 95% CI: 0.91 to 0.96~~) with a difference of the medians of 0.16 cm (95% CI: 0.03 to 0.29~~, Figure 5). Finally, there was a very good level of agreement in the classification of the fetal head position between midwives and obstetricians (K_w=0.89; 95% CI: 0.80 to 0.98). The results were visually confirmed by analysis of both correlation and Bland-Altman graphs.

According to the Bland Altman method, for AoP, the mean of differences (bias) was -2.21 with a 95% CI from -4.37 to -0.04. The upper limit of agreement was 19.96 (95% CI from 16.2 to 23.71) and lower limit of agreement was -24.37 (95% CI from -28.12 to -20.61). For HPD, the mean of differences was -0.02 with a 95% CI from -0.19 to 0.15. The upper limit of agreement was 1.7 (95% CI from 1.41 to 2.00) and lower limit of agreement was -1.75 (95% CI from -2.04 to -1.45). For CD, the mean of differences was 0.23 with a 95% CI from 0.07 to 0.38. The upper limit of agreement was 1.73 (95% CI from 1.47 to 2) and lower limit of agreement was -1.28 (95% CI from -1.55 to -1.01).

DISCUSSION

Main findings

In this study, we have found that, firstly, following a training course that includes a short theoretical description of the techniques and *hands-on* training, attending midwives and obstetricians with very different levels of experience in ultrasound can acquire the necessary skills to perform transperineal/transabdominal ultrasound to assess fetal head position and labor progress and, secondly, there is a good to very good agreement between ultrasound examinations performed by midwives and those performed by obstetricians.

Comparison with previous studies

Two previous studies have evaluated the level of agreement between midwives and obstetricians when measuring the AoP[17, 22]. The first study[17] was designed to evaluate AoP and the head-symphysis distance. To measure these, the fetal head must reach the inferior border of the pubic symphysis. Therefore, the cases were in more advanced stages of labor than in our study. In this study, 11 different midwives performed 30 assessments of the AoP and compared their measurements to those obtained by obstetricians. They only found a moderate agreement between the two groups of operators (ICC: 0.76, 95% CI: 0.55 to 0.88). Training was provided as a one-hour slideshow presentation, but only one supervised assessment was undertaken to complete the training.

In comparison, we provided individualized hands-on training, and only when the trainer considered that the operator was ready were the five mandatory ultrasound examinations requested. In another study[22], one single experienced obstetrician performed 44 transperineal ultrasound examinations of women in prolonged second stage of labor with the fetus in the occiput anterior position and the stored images were

subsequently evaluated by three midwives without ultrasound experience, three junior and three senior obstetricians. Although not statistically different, the authors reported lower reliability when the measurements were performed by the midwives (ICC: 0.61, 95% CI: 0.43 to 0.74) than by the junior (ICC: 0.81, 95% CI: 0.71 to 0.88) or senior (ICC: 0.82, 95% CI: 0.70 to 0.89) obstetricians. Although the assessment of still images eliminates any variations merely due to the time passed between assessments, it inevitably implied a major limitation since it did not consider variability related to different acquisitions.

Limitations and strengths

The main limitation of our study is that most of the assessments (n=72) were carried out during the latent phase of labor when cervical dilatation is below three centimeters; therefore, our results may not be applicable when the labor progression is greater. Although ultrasound examination during the early stages of labor may indeed overestimate the reliability of the measurement of the CD by ultrasound[16,23], the opposite effect is expected for the measurement of the AoP or HPD since the anatomical landmarks are difficultly seen when the fetal head is high. We also acknowledge that the paired classifications of the fetal head position were unavailable in about 25% of the cases. Since this is the most easily obtained variable, we believe that the reason why this was not recorded was that the researchers forgot to do so and not because they could not determine it. However, since the confidence interval of the K_w was still very narrow, it is unlikely that this is affecting the results.

Regarding the time between ultrasound scans performed by obstetricians and midwives, although a difference of up to one hour between the examinations can be very long, more than twenty minutes was exceptional and only happened in nulliparous women who were in the latent phase of labor, so its impact would be minimal[24].

The main strength of our study derives from being a large prospective study involving attending midwives and obstetricians with no previous experience in transperineal ultrasound in labor in a real clinical setting. This allows fair conclusions to be drawn concerning the feasibility of using transperineal ultrasound for routine monitoring of labor progress, irrespective of the type of healthcare professionals managing the labor. In addition, our comparison groups did not only differ in their position but also their level of expertise with ultrasound, which might have allowed indirect evaluation of experience as a limiting factor.

Clinical implications

We have demonstrated that following appropriate training, ultrasound assessment of the fetal head position and the progress of labor can be effectively performed by attending midwives without prior experience in ultrasound. This may help change the perception that ultrasound is a tool reserved for clinicians. The introduction of ultrasound for managing labor and birth by midwives may help reduce the number of vaginal examinations and, therefore, secondary infection. In addition, since ultrasound allows a more objective and visual way of assessing the progress of labor, this may help prospective parents better understand deviations from normal directly from their caring midwife before the doctor is called into the room and takes any action.

Conclusions

Following appropriate training, ultrasound assessment of the fetal head position and the progress of labor can be effectively performed by attending midwives with no prior experience in ultrasound. The level of agreement between the attending midwives and obstetricians with more experience in ultrasound is either good or very good.

AUTHOR CONTRIBUTIONS

Conceptualization: AMF, RM, MMG, LCP.

Data curation: AMF, RM, IFB, NA, SM, AA, MJC, EC, VR, BS, MMG, LCP

Formal analysis: AMF, RM, MMG, LCP.

Investigation: AMF, RM, IFB, NA, SM, AA, MJC, EC, VR, BS, MMG, LCP

Methodology: AMF, RM, MMG, LCP.

Project administration: MMG, LCP

Supervision: MMG, LCP

Validation: AMF, RM, IFB, NA, SM, AA, MJC, EC, VR, BS, MMG, LCP

Writing – original draft: AMF, RM, MMG, LCP.

Writing – review & editing: AMF, RM, IFB, NA, SM, AA, MJC, EC, VR, BS, MMG, LCP

ACKNOWLEDGEMENTS

The authors are grateful to Fundación para la Investigación y el Desarrollo de la Medicina Materno-Fetal y Neonatal, *iMaterna* (Registry No: 2148) for supporting the study and to General Electrics (GE Medical Systems, Zipf, Austria) for providing a Voluson S8 ultrasound machine to carry out this study. Finally, we also wish to thank all the midwives, obstetricians and pregnant women who participated in the study

CONFLICTS OF INTEREST

The authors report no conflict of interest.

Funding statement: This study was conducted thanks to a grant by Fundación para la Investigación y el Desarrollo de la Medicina Materno-Fetal y Neonatal, *iMaterna* (Registry No: 2148). General Electrics (GE Medical Systems, Zipf, Austria) provided a Voluson S8 ultrasound machine to carry out this study. None of these funding sources had any role in the study design, data collection, data analysis or interpretation, writing of the report or decision to submit the article for publication.

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Table 1. Maternal and pregnancy characteristics of the study population.

Variable	Values
Age (years)	34.8 (30.8, 38.4)
Gestational age (weeks)	40.0 (38.9, 41.2)
Pre-pregnancy weight (kg)	64.0 (57.0, 72.0)
Increase in weight (kg)	13.0 (9.4, 16.5)
Parity	
Nulliparous	67 (61.5)
Multiparous	42 (38.5)
Previous caesarean section	10 (23.8)
Method of conception	
Spontaneous	99 (90.8)
Assisted	10 (9.2)
Diabetes Mellitus	
Gestational	9 (8.3)
Pre-gestational	1 (0.9)
Cigarette smoking	11 (10.1)
Less than 3 centimetres dilatation	72 (66.1)
Rupture of membranes prior to assessment	56 (51.4)
Epidural anaesthesia at examination	31 (28.4)
Mode of delivery	
Caesarean section	20 (18.3)
Normal vaginal	63 (57.8)
Instrumental vaginal	26 (23.9)

Data are given as median (interquartile range) or n (%).

Table 2. Results from examinations performed by each group.

Examination	n	Midwives	Obstetricians	Pairwise absolute differences
Angle of progression (degrees)*	107	102 (92 to 116)	102 (89 to 110)	7 (3.5 to 11.5)
Head to perineum distance (cm)	106	4.3 (3.7 to 5)	4.3 (3.5 to 5.1)	0.5 (0.3 to 0.9)
Cervical dilatation (cm)*	97	1.3 (0.7 to 2.9)	1.5 (0.7 to 3)	0.3 (0.1 to 0.7)
Fetal head position*	79			
Quadrant 1		18 (22.8)	18 (22.8)	
Quadrant 2		23 (29.1)	23 (29.1)	
Quadrant 3		15 (19.0)	14 (17.7)	
Quadrant 4		23 (29.1)	24 (30.4)	

Data are given as median (interquartile range) or n (%). ~~Significant differences are noted with a *.~~

Figure legends

Figure 1. Ultrasound measurements of a) angle of progression; b) head-to-perineum distance; c) cervical dilatation

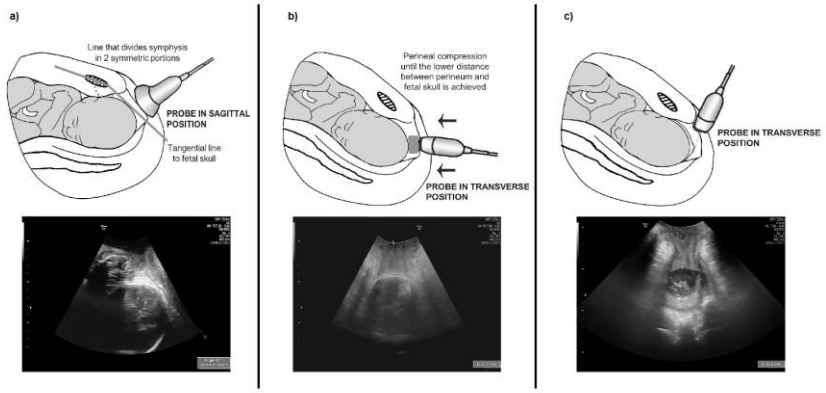

Figure 1. Ultrasound measurements of a) angle of progression; b) head-to-perineum distance; c) cervical dilatation

Figure 2. Quadrants representing the position of the fetal head attending to the location of the lambda fontanelle.

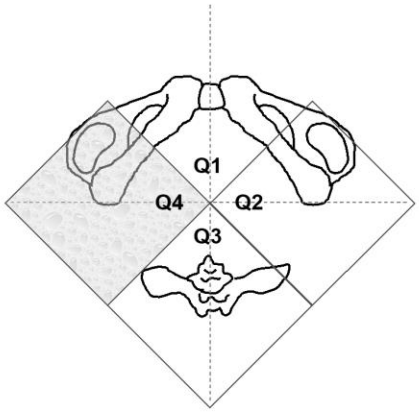

Figure 2. Quadrants representing the position of the foetal head attending to the location of the lambda fontanelle.

Figure 3. a) Bland-Altman plot for the angle of progression. Solid line represents the mean of the differences, dotted lines are limits of agreement, dashed lines are 95% confidence intervals and dot-dashed line is the regression line. b) Scatter plot for the angle of progression from obstetricians and midwives. Dot-dashed line is the regression line and diagonal is the perfect agreement. ~~In blue perfect correspondence and in red linear regression line.~~

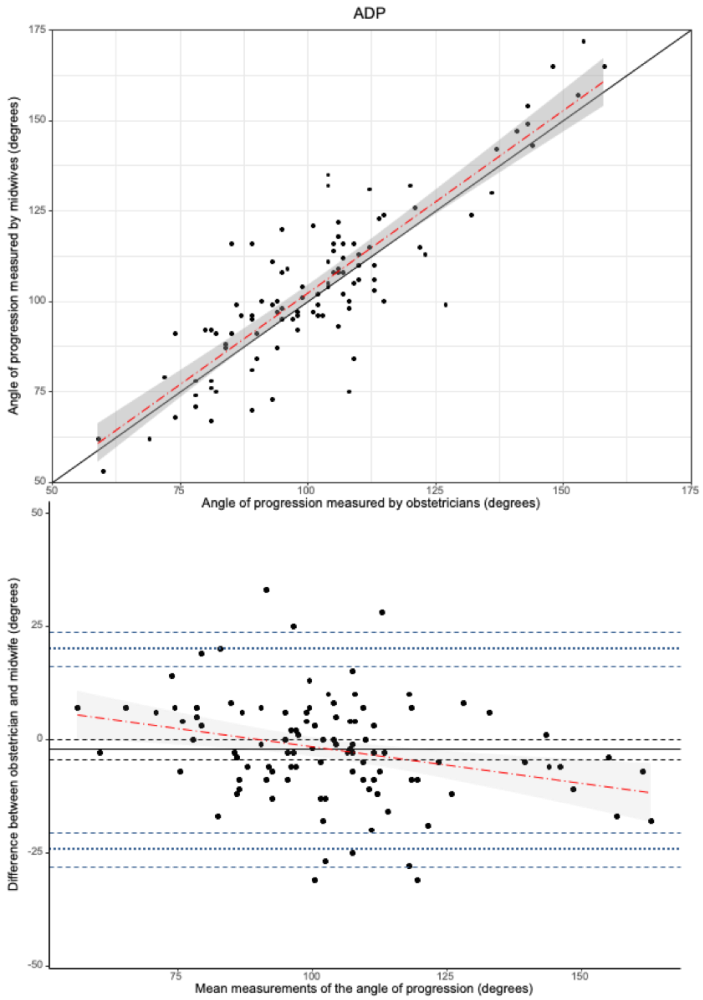

Figure 3. a) Bland-Altman plot for Angle of Progression. b) Scatter plot for Angle of Progression from obstetricians and midwives.

Figure 4. a) Bland-Altman plot for the head-to-perineum distance. Solid line represents the mean of the differences, dotted lines are limits of agreement, dashed lines are 95% confidence intervals and dot-dashed line is the regression line. b) Scatter plot for the head-to-perineum distance from obstetricians and midwives. Dot-dashed line is the regression line and diagonal is the perfect agreement. ~~b) Scatter plot for the head-to-~~

perineum distance from obstetricians and midwives. In blue perfect correspondence and in red linear regression line.

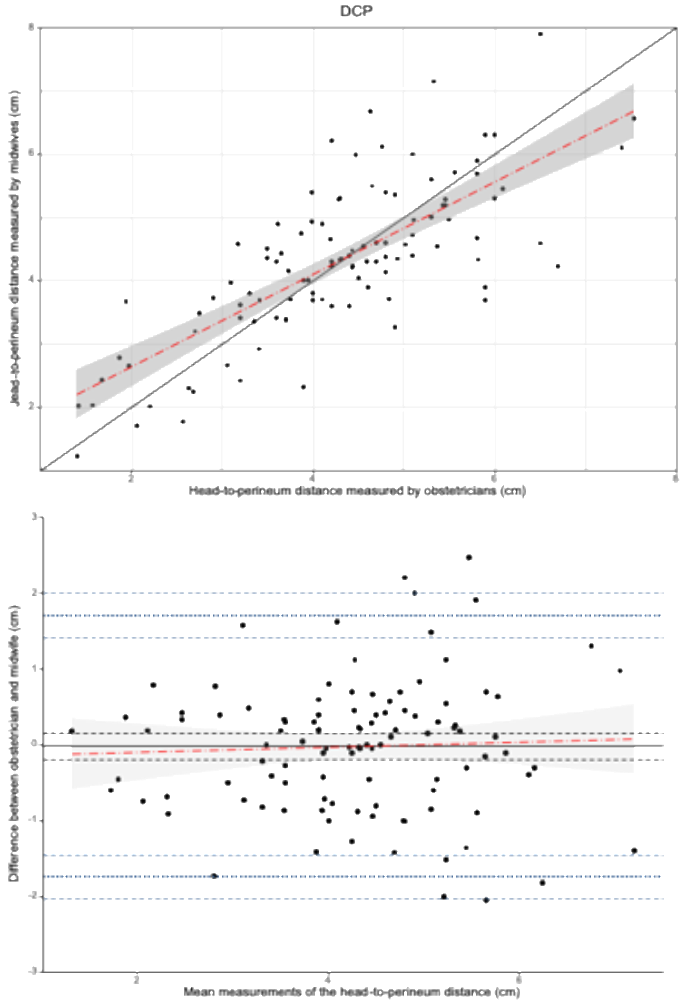

Figure 4. a) Bland-Altman plot for the head-to-perineum distance. b) Scatter plot for the head-to-perineum distance from obstetricians and midwives.

Figure 5. a) Bland-Altman plot for the cervical dilatation. Solid line represents the mean of the differences, dotted lines are limits of agreement, dashed lines are 95% confidence intervals and dot-dashed line is the regression line. b) Scatter plot for the cervical

dilatation from obstetricians and midwives. Dot-dashed line is the regression line and diagonal is the perfect agreement.~~a) Bland-Altman plot for the cervical dilatation. b) Scatter plot for the cervical dilatation from obstetricians and midwives. In blue perfect correspondence and in red linear regression line.~~

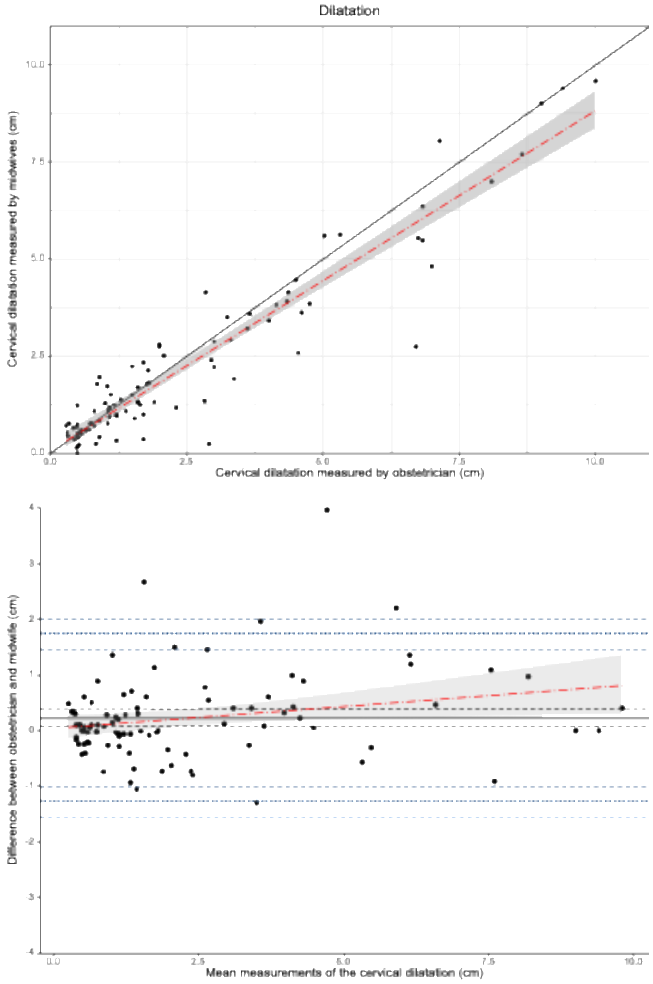

Figure 5. a) Bland-Altman plot for the cervical dilatation. b) Scatter plot for the cervical dilatation from obstetricians and midwives.